

Exploring the Mechanism of Promoting Green Innovation through Digital Transformation Based on ESG Concept

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Abstract: Starting from the perspective of ESG philosophy, this article systematically discusses the mechanism by which digital transformation promotes the development of green innovation in enterprises. The study suggests that digital transformation faces bottlenecks in technology integration and management process optimization, while the acquisition, quality, and standardization of ESG data, as well as the balancing challenges of green innovation costs and benefits, limit the sustainable development capabilities of enterprises. By delving into the various applications of ESG in business operations, including but not limited to reporting systems, information disclosure, risk management, and strategic decision-making, this paper aims to elucidate the role of digital transformation in various environmental factors and how social and corporate governance dimensions promote green innovation practices through data transparency, risk warning, and governance optimization. Finally, this article proposes a comprehensive mechanism model to emphasize the systematic response formed by the multidimensional collaborative development of digital technology, ESG concepts, and green innovation, in order to provide theoretical support and practical reference for the sustainable development of enterprises under policy pressure and market competition environment.

1. Introduction

Digital technology plays a role in optimizing enterprise resources, restructuring production processes, and data-driven decision-making, but the coordination mechanism for technology integration and organizational management is not yet mature; The differential impact of standardized ESG data acquisition and quality control mechanisms on cross industry comparisons and regulatory judgments; The balance between cost input and expected returns in green innovation has become an important constraint in corporate strategic allocation. The study analyzed the internal mechanism of digital transformation's role in promoting green innovation from three dimensions: institutional framework, operational mechanism, and technological implementation. It also discussed how to use digital platforms under ESG constraints to improve environmental performance, strengthen social responsibility compliance, optimize governance structure, and achieve effective connection between institutional paths and technological support. Empirical

analysis and policy recommendations were made for the sustainable development strategy of enterprises.

2. Problems and challenges

2.1 Technological and management bottlenecks in digital transformation

Digital transformation presents multi-level and cross domain bottleneck issues in internal operations and strategic frameworks of enterprises, with conflicting technology adoption and organizational management, and increased complexity in integrating technology infrastructure and business processes. On the one hand, the new generation of digital technologies such as cloud computing, the Internet of Things, and big data analysis can theoretically improve the efficiency of enterprise resource allocation. However, in the specific implementation process, they often encounter difficulties in integrating legacy systems, widespread data silos, and a lack of real-time data processing capabilities, making it difficult to fully unleash the potential of digital technology. On the other hand, management must coordinate the conflicting goals and overlapping functions among different departments when promoting digital strategies, and the existing organizational structure and process inertia have become important constraints on technology implementation. On a global scale, many enterprises encounter execution deviations and insufficient resource allocation in the implementation of the "last mile" of digitalization. This is not only reflected in delays and budget overruns in information technology projects, but also in the lack of cross departmental data governance mechanisms and continuous cultivation mechanisms for technical talent teams. This mismatch between technology and management further affects the overall effectiveness of digital transformation.

2.2 ESG data acquisition, quality, and standardization issues

In the process of popularizing ESG concepts, obstacles at the data level are widely present and becoming increasingly significant, especially the problems of incomplete data acquisition channels, data quality, and standardization systems, which have become the most core issues that plague enterprises in implementing environmental, social, and governance matters. ESG data mostly comes from reporting systems of multiple departments, covering information such as environmental emission records, employee data, and governance performance. These data are usually scattered in the supply chain, operational systems, and financial systems, and there is no unified standard data interface or real-time update machine, resulting in high data integration costs and error rates. Due to the lack of a unified ESG reporting standard globally, various frameworks (such as GRI, SASB, TCFD, etc.) have differences in indicator systems, disclosure requirements, and evaluation methods, making data comparable and limiting cross regional analysis. The issue of data quality is manifested in inconsistent, disorganized formats, and a lack of independent verification mechanisms in enterprise reports, which not only affects the accuracy of enterprise risk management, but also challenges the trust of investors and regulatory agencies in ESG performance.

2.3 Cost benefit balance in the implementation of green innovation

Green innovation is the most core part of a company's sustainable strategy, and the dynamic balance between costs and benefits demonstrated in implementation involves multidimensional factors such as resource allocation, technology selection, and market feedback. In the process of promoting green innovation projects such as low-carbon technology, clean production processes, recycling strategies, and energy-saving management systems, enterprises often encounter practical

challenges such as high initial costs, uncertainty of technological risks, and long return cycles. Compared to traditional production lines, the introduction of green technology may require the purchase of advanced equipment, optimization of energy structure, and adjustment of supply chain design, which will increase the pressure on capital expenditure and operating costs in the short term. Traditional financial indicators are difficult to instantly reflect the value brought by green innovation, sustainable products are accepted by the market, and price premiums have not yet formed a stable expectation, which further increases the difficulty of evaluating future return uncertainty in company investment decisions. Despite the promotion of global policies and the increase in consumer environmental awareness, innovation in green technologies can enhance a company's brand competitiveness, reduce long-term operational risks, and obtain policy incentives and subsidies in specific markets. However, the contradiction between cost recovery period and investment return rate remains the primary issue limiting companies from fully implementing green innovation.

3. The Application of ESG in Enterprise Operations

3.1 ESG reporting system and information disclosure system

With the tightening of the global regulatory environment and the increasing demand for market transparency, ESG reports are gradually transitioning from voluntary disclosure to structured requirements. Several jurisdictions have introduced or improved relevant institutional frameworks to regulate the disclosure of data on corporate environmental, social, and governance performance^[1]. Major exchanges in Chinese mainland have also included ESG related information in the disclosure obligations of listed companies, urging them to display non-financial information in their annual reports and social responsibility reports, enhancing regulatory compliance and external transparency.

3.2 ESG and Enterprise Risk Management

The position of ESG in the enterprise risk management system is expanding, which has an impact on risk identification, evaluation, and mitigation mechanism construction. From the perspective of risk management practice, enterprises not only need to identify traditional financial and operational risks, but also need to integrate physical and transformation risks caused by climate change, supply chain social risks, and governance process compliance risks into a unified management framework^[2]. This determines that risk assessment models must involve broader variables and situational analysis. Modern enterprises establish an integrated ESG risk management platform to enable real-time interaction between non-financial information such as environmental emission data, employee protection indicators, and regulatory compliance records and the enterprise risk indicator system, thereby reflecting uncertain factors related to sustainable development into comprehensive risk assessment. Solutions like IBM OpenPages on the market integrate ESG risks into traditional enterprise risk management processes through risk assessment dashboards and compliance monitoring modules, placing risk levels, mitigation strategies, and performance indicators in the same governance logic and achieving dynamic updates. Due to the involvement of multiple stakeholders, social responsibility risks, supply chain interruption risks, and environmental regulatory change risks, these topics continue to be important research topics from the macro risk perspective of enterprises. Therefore, senior management strategy formulation and risk committees often incorporate ESG risks into quarterly or even monthly risk review mechanisms to promote foresight and response capabilities for destructive risks with long-term value.

3.3 The impact of ESG on corporate strategic decision-making

The ESG concept is gradually permeating into the strategic decision-making level of enterprises and influencing their core evaluation of capital allocation, market positioning, long-term investment return expectations, and organizational governance design. The attention of the capital market to the ESG performance of companies has been integrated into the investment analysis process. While evaluating traditional financial indicators, investors also value how to measure a company's risk exposure and sustainability through ESG indicators. This trend drives companies to consider the role of ESG elements in their business models and value chains when formulating medium - and long-term strategies^[3]. According to the guidelines issued by the International Sustainability Standards Board, companies should comprehensively consider the identified significant sustainability risks and opportunities when disclosing strategic information, in order to analyze their impact on current business models, the impact of resource allocation on future cash flows, and the need for reports to demonstrate the flexibility of strategies and response plans, so as to shift ESG issues from supportive reports to strategic core. The internal strategic committee and senior management of a company generally weigh the investment and expected return on investment in achieving net zero emissions goals, fulfilling social responsibilities, and improving governance effectiveness. This multidimensional balance drives the expansion of the strategic planning cycle and strengthens the consideration of different stakeholders.

4. The promotion mechanism of digital transformation based on ESG concept for green innovation

4.1 Promotion mechanism of environmental dimension

From an environmental perspective, the integration of digital transformation and ESG concepts can promote green innovation by improving environmental information transparency, optimizing resource utilization efficiency, and strengthening pollution control measures^[4]. Enterprises utilize big data, cloud computing, sensor networks, and other technologies to achieve precise monitoring of energy consumption, emission indicators, and resource recycling, providing basic data support for accurate low-carbon strategy formulation. The application of digital technology has a significant positive impact on green innovation achievements, partly due to the mediating role of digitalization in improving environmental performance; Research is conducted on enterprises in heavily polluting industries, and it is pointed out that digital transformation can improve their ESG performance and play a mediating role in the quality of environmental information disclosure. That is, the enhancement of digital governance capabilities in the environmental dimension of enterprises can directly promote the output of environmental green innovation achievements. At present, the policy promotion of environmental protection goals such as "carbon peak" and "carbon neutrality" in society has also prompted enterprises to establish a stronger institutional driving force between digital investment in the environment and green innovation strategies. It is necessary for enterprises to apply digital technology to strengthen pollutant emission monitoring and environmental risk prediction work, and thus form a standardized technical route for green product research and development and clean production processes.

4.2 Promotion mechanism of social dimension

From a social perspective, the driving mechanism for the integration of digital transformation and ESG concepts is manifested in multiple aspects such as employee welfare protection, improvement of working conditions, implementation of supply chain social responsibility, and

community relationship management^[5]. Enterprises can achieve real-time access and analysis of employee health and safety data through digital platforms, making risk prevention and control measures more refined and predictable, thereby promoting the effectiveness of social performance indicators. Digital solutions with innovation capability as the core can also enhance social participation and external supervision mechanisms, such as disclosing social responsibility indicators to investors and the public through open data interfaces, increasing trust and social capital accumulation. In promoting the practice of corporate social responsibility, such mechanisms require both digital optimization of the internal labor structure and welfare mechanisms of the enterprise, as well as continuous tracking of the social performance of supply chain partners, in order to ensure the compliance and fairness of the entire social value creation process. The effect of digital transformation on improving ESG performance of different types of companies is heterogeneous, and from a social perspective, it presents an effect of enhancing the attention of employees and stakeholders. Therefore, it can be seen that digital management of social responsibility indicators plays a significant mediating role in the green innovation ecosystem.

4.3 Promotion mechanism of corporate governance dimension

From the perspective of corporate governance, digital transformation promotes green innovation by strengthening internal control systems within the ESG framework, enhancing governance transparency, and strengthening the scientific nature of decision support systems. Integrating digital management tools, such as enterprise resource planning systems (ERP) and risk management analysis platforms, into the internal governance structure of enterprises can help enhance compliance risk management, data quality, and performance indicator control capabilities. These changes can promote governance efficiency, increase risk indicators in long-term development strategies, and provide support for the selection of green innovation strategic paths. Existing empirical research has shown that digital transformation significantly promotes the improvement of green innovation levels in enterprises by strengthening internal control capabilities. This mechanism is particularly reflected between technology intensive enterprises and high-tech enterprises, where the maturity of digital governance systems is equally related to the input-output of green innovation in enterprises. The digitalization of corporate governance also enables the board of directors, supervisory board, and risk control committee to obtain real-time data on environmental and social performance during the strategic planning process, thereby achieving the goal of dynamic adjustment of green development by the governance layer. This mechanism integrates various dimensions of ESG indicators into the performance evaluation system, helping enterprises form stable constraints and incentive mechanisms for green innovation tasks from the governance structure level.

4.4 Integrated Mechanism Model

The comprehensive mechanism model emphasizes that the promotion of green innovation in ESG concepts through digital transformation is not a linear impact on a single dimension, but rather a systematic synergistic effect generated by the combination of environmental, social, and governance factors. Under this comprehensive model, digital technology is the common support of underlying infrastructure and governance logic, and also provides underlying data capabilities for environmental performance monitoring, social responsibility practices, and corporate governance optimization; The ESG concept regulates the direction and priority of digital investment through institutional constraints and strategic guidance. Previous studies have suggested that this collaborative mechanism exhibits multiple configuration paths for achieving high-level green innovation. For example, the combination of social governance and digital management under some

configurations can promote the improvement of green innovation performance by strengthening the fulfillment of social responsibility and optimizing internal processes, while promoting the deep integration of environmental governance and digital technology R&D in other configurations is more conducive to achieving technological breakthroughs in green innovation. This multi-path model indicates that a single factor is not necessary for high-level achievements in green innovation. It is the product of the interaction of multiple factors within the overall system. The comprehensive mechanism model constructed from this provides a theoretical and empirical basis for explaining the complex relationship between digital transformation, ESG implementation, and green innovation, and also provides an analytical framework for the formulation of differentiation strategies for enterprises.

5. Conclusion

By systematically analyzing the combination of digital transformation and ESG concepts, it can be seen that whether green innovation can be achieved depends not only on the improvement of technological capabilities, but also on the institutionalization, standardization of data governance, and optimization of management systems. From an environmental perspective, digitalization provides technological means for enterprises to monitor in real-time, optimize resource utilization, and significantly improve environmental performance; From a social perspective, digital empowerment of social responsibility indicator management has been achieved, and stakeholder supervision and participation have been strengthened; From the perspective of corporate governance, digital means enhance the transparency of governance and the scientificity of decision-making, thereby achieving optimized allocation of resources and reduction of strategic risks. The interaction between digital transformation and ESG practices promotes the efficiency and effectiveness of green innovation in enterprises through multi-path and multi-level mechanisms. In the future, enterprises should continuously improve their ESG data standardization system, strengthen the construction of technology platforms, and establish long-term incentive mechanisms from a governance structure based on policy guidance and market demand. They should organically integrate digitalization, green innovation, and sustainable development strategies to provide a stable development path for enterprises under global competition and environmental constraints.

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